surface hinge moments are based on reliable data. In applying this criterion, the effects of servo mechanisms, tabs, and automatic pilot systems, must be considered.

(c) *Limit pilot forces and torques.* The limit pilot forces and torques are as follows:

| Control | Maximum forces or torques | Minimum forces or torques |
|---|---|---|
| Aileron: | | |
| Stick | 100 lbs | 40 lbs. |
| Wheel [1] | 80 D in.-lbs [2] | 40 D in.-lbs. |
| Elevator: | | |
| Stick | 250 lbs | 100 lbs. |
| Wheel (symmetrical) | 300 lbs | 100 lbs. |
| Wheel (unsymmetrical) [3] | | 100 lbs. |
| Rudder | 300 lbs | 130 lbs. |

[1] The critical parts of the aileron control system must be designed for a single tangential force with a limit value equal to 1.25 times the couple force determined from these criteria.

[2] *D*=wheel diameter (inches).

[3] The unsymmetrical forces must be applied at one of the normal handgrip points on the periphery of the control wheel.

[Doc. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–38, 41 FR 55466, Dec. 20, 1976; Amdt. 25–72, 55 FR 29776, July 20, 1990]

### § 25.399 Dual control system.

(a) Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than—

(1) 0.75 times those obtained under § 25.395; or

(2) The minimum forces specified in § 25.397(c).

(b) The control system must be designed for pilot forces applied in the same direction, using individual pilot forces not less than 0.75 times those obtained under § 25.395.

### § 25.405 Secondary control system.

Secondary controls, such as wheel brake, spoiler, and tab controls, must be designed for the maximum forces that a pilot is likely to apply to those controls. The following values may be used:

PILOT CONTROL FORCE LIMITS (SECONDARY CONTROLS)

| Control | Limit pilot forces |
|---|---|
| Miscellaneous: | |
| *Crank, wheel, or lever | ((1 + R) / 3) × 50 lbs., but not less than 50 lbs. nor more than 150 lbs. (R=radius). (Applicable to any angle within 20° of plane of control). |
| Twist | 133 in.–lbs. |
| Push-pull | To be chosen by applicant. |

*Limited to flap, tab, stabilizer, spoiler, and landing gear operation controls.

### § 25.407 Trim tab effects.

The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot, and the deflections are—

(a) For elevator trim tabs, those required to trim the airplane at any point within the positive portion of the pertinent flight envelope in § 25.333(b), except as limited by the stops; and

(b) For aileron and rudder trim tabs, those required to trim the airplane in the critical unsymmetrical power and loading conditions, with appropriate allowance for rigging tolerances.

### § 25.409 Tabs.

(a) *Trim tabs.* Trim tabs must be designed to withstand loads arising from all likely combinations of tab setting, primary control position, and airplane speed (obtainable without exceeding the flight load conditions prescribed for the airplane as a whole), when the effect of the tab is opposed by pilot effort forces up to those specified in § 25.397(b).

(b) *Balancing tabs.* Balancing tabs must be designed for deflections consistent with the primary control surface loading conditions.

(c) *Servo tabs.* Servo tabs must be designed for deflections consistent with the primary control surface loading conditions obtainable within the pilot maneuvering effort, considering possible opposition from the trim tabs.

### § 25.415 Ground gust conditions.

(a) The control system must be designed as follows for control surface

loads due to ground gusts and taxiing downwind:

(1) The control system between the stops nearest the surfaces and the cockpit controls must be designed for loads corresponding to the limit hinge moments H of paragraph (a)(2) of this section. These loads need not exceed—

(i) The loads corresponding to the maximum pilot loads in §25.397(c) for each pilot alone; or

(ii) 0.75 times these maximum loads for each pilot when the pilot forces are applied in the same direction.

(2) The control system stops nearest the surfaces, the control system locks, and the parts of the systems (if any) between these stops and locks and the control surface horns, must be designed for limit hinge moments H, in foot pounds, obtained from the formula, $H=.0034KV^2cS$, where—

V=65 (wind speed in knots)
K=limit hinge moment factor for ground gusts derived in paragraph (b) of this section.
c=mean chord of the control surface aft of the hinge line (ft);
S=area of the control surface aft of the hinge line (sq ft);

(b) The limit hinge moment factor K for ground gusts must be derived as follows:

| Surface | *K* | Position of controls |
|---|---|---|
| (a) Aileron | 0.75 | Control column locked or lashed in mid-position. |
| (b) .....do | [1] 1 ±0.50 | Ailerons at full throw. |
| (c) Elevator | [1] 1 ±0.75 | (c) Elevator full down. |
| (d) .....do | [1] 1 ±0.75 | (d) Elevator full up. |
| (e) Rudder | 0.75 | (e) Rudder in neutral. |
| (f) .....do | 0.75 | (f) Rudder at full throw. |

[1] A positive value of K indicates a moment tending to depress the surface, while a negative value of K indicates a moment tending to raise the surface.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–72, 55 FR 29776, July 20, 1990; Amdt. 25–91, 62 FR 40705, July 29, 1997]

### §25.427 Unsymmetrical loads.

(a) In designing the airplane for lateral gust, yaw maneuver and roll maneuver conditions, account must be taken of unsymmetrical loads on the empennage arising from effects such as slipstream and aerodynamic interference with the wing, vertical fin and other aerodynamic surfaces.

(b) The horizontal tail must be assumed to be subjected to unsymmetrical loading conditions determined as follows:

(1) 100 percent of the maximum loading from the symmetrical maneuver conditions of §25.331 and the vertical gust conditions of §25.341(a) acting separately on the surface on one side of the plane of symmetry; and

(2) 80 percent of these loadings acting on the other side.

(c) For empennage arrangements where the horizontal tail surfaces have dihedral angles greater than plus or minus 10 degrees, or are supported by the vertical tail surfaces, the surfaces and the supporting structure must be designed for gust velocities specified in §25.341(a) acting in any orientation at right angles to the flight path.

(d) Unsymmetrical loading on the empennage arising from buffet conditions of §25.305(e) must be taken into account.

[Doc. No. 27902, 61 FR 5222, Feb. 9, 1996]

### §25.445 Auxiliary aerodynamic surfaces.

(a) When significant, the aerodynamic influence between auxiliary aerodynamic surfaces, such as outboard fins and winglets, and their supporting aerodynamic surfaces, must be taken into account for all loading conditions including pitch, roll, and yaw maneuvers, and gusts as specified in §25.341(a) acting at any orientation at right angles to the flight path.

(b) To provide for unsymmetrical loading when outboard fins extend above and below the horizontal surface, the critical vertical surface loading (load per unit area) determined under §25.391 must also be applied as follows:

(1) 100 percent to the area of the vertical surfaces above (or below) the horizontal surface.

(2) 80 percent to the area below (or above) the horizontal surface.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–86, 61 FR 5222, Feb. 9, 1996]

### §25.457 Wing flaps.

Wing flaps, their operating mechanisms, and their supporting structures